



## City Research Online

### City, University of London Institutional Repository

---

**Citation:** Botting, N. & Baraka, N. (2017). Sleep behaviour relates to language skills in children with and without communication disorders. *International Journal of Developmental Disabilities*, doi: 10.1080/20473869.2017.1283766

This is the accepted version of the paper.

This version of the publication may differ from the final published version.

---

**Permanent repository link:** <https://openaccess.city.ac.uk/id/eprint/16168/>

**Link to published version:** <https://doi.org/10.1080/20473869.2017.1283766>

**Copyright:** City Research Online aims to make research outputs of City, University of London available to a wider audience. Copyright and Moral Rights remain with the author(s) and/or copyright holders. URLs from City Research Online may be freely distributed and linked to.

**Reuse:** Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

---

---



Botting, Nicola & Baraka, Nebras (in press, 2017) Sleep behaviour relates to language skills in children with and without communication disorders, *International Journal of Developmental Disabilities*.

Centre for Language and Communication Science Research, City University of London

Nicola.botting.1@city.ac.uk; 020 7040 8314

**Sleep behaviour relates to language skills in children with and without  
communication disorders**

**Abstract**

**BACKGROUND:** Sleep problems are common in children with autism spectrum disorder (ASD). There is also emerging evidence that sleep quality influences language learning in typical development. However there is a gap within the literature in regards to sleep and developmental language disorder in children (DLD).

**OBJECTIVES:** The aims of this study were to: i) compare sleep patterns of children with communication disorders to the sleep patterns of their typical peers, and ii) ascertain whether sleep patterns related to language in this sample.

**METHOD:** The relationship between sleep and language was investigated via parental questionnaires. There were sixty-five child participants in total aged between 3-18 years. Parents reported on 28 children with a developmental communication disorder (CD; ASD n=8 or DLD n=20) and 37 who were typical developing.

**RESULTS:** The children with a developmental communication disorder showed more sleep problems than their typical peers particularly in terms of getting to sleep and early waking. Furthermore, significant correlations were found between sleep behaviour and language for children in both groups.

**CONCLUSION:** Children with CD may have poorer sleep patterns than their typical peers which could compound developmental language difficulties.

## **Introduction**

Language and communication are key aspects of cognitive function in everyday life and there is now evidence that sleep plays an important role in consolidating these aspects of development in typical children (Williams et al., 2014; Henderson et al, 2012; Fenn et al, 2003) as well as in adults (Tamminen, 2007; Kurdziel et al, 2016). Notably, sleep has been found to boost learning of novel experimental words in childhood (see Axelsson et al, 2016 for an overview) and even in babies as young as 6 months (Simon et al, 2016). Sleep patterns also associate with school achievement (Gruber et al, 2014). However previous studies examining associations between sleep *problems* and language have largely recruited children with known sleep difficulties and subsequently reported their language skills (e.g., Dahl, 1996; Lim & Dinges, 2010). An alternative way to explore the same association is to examine sleep behaviours in children with known language difficulties; however there is very little research in this area.

Two main groups of children with communication difficulties are those with developmental language disorder (DLD – sometimes referred to as Specific Language Impairment but see Bishop, 2014; Bishop et al 2016) and those with autism spectrum disorder (ASD). On average the prevalence of DLD is 7% in children (Tomblin et al, 1997) and 1% for ASD (Taylor et al, 2013), together representing a substantial population of children. Both of these disorders share deficits in communication and also some familial heritability (Conti-Ramsden et al, 2006). Thus there is a good deal of overlap but it is not clear to what degree their aetiology or wider symptoms such as sleep are shared (see Williams et al. 2008, for a discussion).

Children with ASD have been studied extensively in relation to sleep difficulties, showing an increased prevalence in this group. Mannion & Leader (2014) reviewed these studies and reported a range of prevalence rates from 33% (Goldman et al, 2011) to 80.9% (Mannion, Leader & Healy, 2013). Sleep difficulties include time getting to sleep and night-waking, but at the clinical level sleep disorders are predominantly described as insomnia (Cohen et al, 2014) or as ‘unspecified’ (Malow et al, 2016). The review by Cohen and colleagues (2014) attempted to unpick some of the relationships between sleep and behaviour in children with ASD. Their report tentatively concludes that sleep difficulties lead to an increase in autistic symptoms and challenging behaviour (p.8).

Many of the studies reviewed here also point to increased ADHD symptoms related to poor sleep. Children with ASD (Tureck and Matson, 2013) and children with DLD (Cohen et al, 2000) are both at high risk of having co-morbid ADHD, which in turn is also associated with sleep disorder (Schneider, Lam & Mahone, 2016).

However within the existing literature, language has rarely been an outcome measure, and is often not even included in participant descriptions. Only one paper included in Cohen et al (2014) reported on verbal skills (Taylor et al, 2012). One reason for this omission may be that not all children with ASD are felt to have linguistic difficulties (DSMV, 2015). Nevertheless, all children with autism will by definition have some impairment in communication, and thus it is still surprising that this has not been a focus of the literature to date.

To our knowledge, there is only one published study of sleep in children with language delay, as part of a wider cohort study (Dionne et al, 2011). In their longitudinal study, 5 year old children with language delay were found to have less mature sleep-wake patterns at 6 and 18 months than children without delay. More studies in this area could be useful information, both clinically and theoretically. Cohen et al (2014) note that sleep is often absent from intervention strategies for families of children with autism (perhaps with the exception of medication, see Malow et al, 2016), and this is also true for families of children with DLD. If children with DLD are found to have sleep difficulties this opens a theoretical question about whether autistic children with additional linguistic impairment are the same subgroup as those with sleep disturbance.

### **Present study**

The focus of this study was to compare sleep patterns of children with DLD and ASD to the sleep patterns of their typical peers using parental survey report. Specifically our research aims are to investigate i) whether sleep is reportedly poorer in children with communication disorders and ii) whether specific sleep behaviours correlate with reported language skill.

## **Methods**

### **Participants**

In total 69 parents completed a survey aimed at parents of children with and without communication disorders. Three parents started the questionnaire but did not agree to the initial consent question and therefore were not able to complete the questionnaire leaving 66 participants. One respondent reported on a child with a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) rather than a communication disorder, and this participant's data was not included here. Only 2 children (both ASD) reported co-morbid diagnoses of ADHD and these children were included. Thus 65 parent survey responses are included in the final analyses. These parents reported on their children who were between the ages of 3-18, 41 male and 24 female. Each parent could only access the survey once, so all of the children reported upon are from different families. Thirty seven of the participants completed the survey about a typically developing child (TD). The mean age of these children was 5;6 (SD=3;9). Twenty eight children had a developmental communication disorder (CD) (mean age=7;1 SD=3;7). Eight of these had ASD and the remaining 20 had LI. There were no significant differences between ASD and LI participants on any demographic or outcome variable except non-verbal communication which was rated by parents as more difficult for ASD children. The CD groups have therefore been combined for the purpose of analysis. There were significantly more boys in the CD group (23/28; 82%) compared to boys in the TD group (18/37; 49%) (Fisher's exact  $p=0.009$ ). This is not unexpected when studying developmental communication disorders using an open recruitment approach. There was no significant difference in age across the two groups ( $p>0.1$ ).

### **Materials**

The survey was a novel questionnaire designed by the second author based on similar surveys (Polimeni, Richdale & Franc, 2005; Robinson & Richdale, 2004; Schrek & Mulick, 2000). The language questions used were scales from the Children's Communication Checklist (Bishop, 1998).

Questions covered 5 main areas but the order of questions was not by topic area, instead items from each area were interspersed during survey presentation:

- i) Demographic information – *Gender; diagnosis; age of diagnosis; current age of the child.*
- ii) Sleep behaviour - *Child's bedtime; time taken to fall asleep; usual duration spent asleep; usual waking time; number of times awake in the night; whether the child sleeps alone at night (yes/no);*
- iii) Reported sleep difficulties - *Restlessness in sleep; problems getting off to sleep; waking earlier than expected by parents for age; interrupted/irregular breathing while asleep. Parents were required to state yes or no.*
- iv) Language – *these questions used scales from the Children's Communication Checklist (Bishop, 1998). This measure is a parent / teacher report measure that has 9 sub-scales tapping into communication (speech, syntax, initiation, coherence, stereotypy; context, rapport, social and interests). Three of these were used for this study: speech (output, intelligibility, fluency, e.g., people can understand virtually everything he or she says); syntax, (complexity of spoken grammar, e.g., speech is mostly two to three word phrases such as "me got ball" or "give dolly"); and coherence (making sense in conversation, e.g., uses terms like "he" and "it" without making it clear what he or she is talking about). The whole questionnaire was felt to be too lengthy for an online survey and these scales were chosen to be indicative of key language difficulties. The CCC has been shown to have good inter-rater reliability (0.80), internal consistency (between 0.80 and 0.87) and validity (Bishop 1998). Each scale comprises a series of statements, and is scored on a scale of how much each statement applies to the individual. The options given are 'does not apply', 'applies somewhat', 'definitely applies' and 'unable to judge'. These responses are numerically coded and summed to give a score for each scale. Parents were also asked to rate overall expressive, receptive and social communication ability using a 5 point scale from 'extremely easy' (1) to 'extremely difficult'(5).*
- v) Other developmental skills – *Parents were asked about the following related developmental skills using the same 5 point scale: Attention and listening, non-verbal communication, memory, reading and writing.*



## **Procedure**

The questionnaires were completed online using a link shared via professionals and social media sites. The questionnaire was hosted using the Survey Monkey research tool. Following ethical approval by the LCS proportionate ethical review panel, City University London, the questionnaire was completed by five individuals as a procedural pilot test. These completed surveys were not used for the final research results but did help in determining the length of time it took for individuals to complete the survey. The time ranged from 8-16 minutes which was deemed to be appropriate. Parents clicking on the web-link were first shown an information and consent page where they were asked to give permission for the collection and use of the data for the described research purpose. The information sheet also explained the questionnaire's length and approximate completion time, instructions and aims. It provided researcher contact information as well as independent complaint procedure directions. Participants were reassured that the survey was voluntary, they could close the link at any time without a penalty of any kind, and that all questionnaire responses were anonymous.

## **Statistical analysis**

Because of the relatively small sample size, simple comparative and associative statistics were performed in the form of t-tests and correlations / chi-square analyses respectively.

## **Results**

### **Language and other developmental skills**

The CCC items confirmed that children with CD had lower language ability than TD peers in speech, syntax and semantic/pragmatic domains.

***Speech problems:*** Children with CD had more speech difficulties (M=12.2, SD=5.07 compared to the TD group (M=5.50, SD=4.13) ( $t(50) = -5.074$ ;  $p < 0.001$ ).

***Syntax problems:*** The CD mean for syntax problems was also significantly lower (M=4.37, SD=2.23) compared to the TD group (M=1.69, SD=2.15) ( $t(60) = -4.785$ ;  $p < 0.001$ ).

***Semantic/pragmatic problems:*** The developmental disorder group had significantly more difficulties with coherence (mean=10.12, SD=4.314) compared to TD peers (mean=3.900, SD=4.088) ( $t(53) = -5.479$ ;  $p < 0.001$ ).

Parents also rated communication and other developmental skills as poorer for the CD group. See table 1 for details.

[Table 1 about here]

### **Sleep behaviour**

On average, the time it took the communication disorder group to sleep was significantly more than the typically developing group. A significant minority of the CD group (9/28; 32%) needed longer than 45mins to fall asleep, whereas the modal response for the TD was a period 10-15mins to fall asleep (18/37; 49%) ( $\chi^2(4) = 11.620, p=0.020$ ). Children with developmental communication disorders were also less likely to sleep alone (16/28; 57%) compared to the TD group (32/37; 86%; Fisher's exact  $p=0.011$ ).

Bedtime was split into three categories: early (18:00-19:30), late (20:00-21:00) and very late (22:00-24:30). There were no significant differences by group with nearly half of the both groups falling into the 'late' category (CD: 12/28; 43%; TD: 15/37; 41%;  $\chi^2 0.599 (2) p=0.741$ ). The duration of time spent asleep also showed no significant difference between the CD group (mean=9.09, SD= 2.62) compared to the TD group (mean=10.14, SD= 1.89) ( $t(63) = 1.832; p=0.072$ ). This was also true for the number of night-time wakings (CD mean= 1.57, SD= 1.574; TD mean= 1.24, SD = 3.55;  $t(63) = -0.455; p=0.650$ ).

### **Sleep difficulties**

There were significantly more participants in the CD group (9/28; 32%) who 'woke up very early for their age' compared to the typical group (1/37; 3%) (Fisher's exact test  $p=0.002$ ).

Results for participants fitting the description of being a 'restless sleeper' showed no significant difference between the CD group (17/28; 60%) compared to the TD group (14/37; 37%) (Fisher's exact test  $p=0.083$ ) but there was a trend for the CD to be more restless. There were also no significant differences between the two groups in having interrupted or irregular breaths during their sleep although again this was slightly higher in the CD group (9/28; 32%) compared to TD peers (6/37; 16%) (Fisher's exact test  $p=0.150$ ).

### **Relationship between sleep patterns and language**

The relationship between sleep and communication and other developmental skills was examined with the whole sample combined. Table 2 shows all correlations between sleep and development, and also with groups separate.

Language ability showed a relationship with sleep behaviour, particularly with difficulties getting off to sleep: There were significant correlations between ‘time getting off to sleep’ and CCC syntax ( $r=0.27$ ,  $p=0.036$ ) and between ‘time getting off to sleep’ and CCC semantic/pragmatic ability ( $r=0.45$ ,  $p=0.001$ ). This factor also correlated significantly with all parent ratings of development except reading and writing. In addition, ‘time spent asleep’ associated significantly with all parent ratings of communication and memory, and the number of night time wakings was correlated significantly to attention and listening, receptive language and memory.

When correlations were examined separately, similar patterns were seen. For both groups, CCC semantic/pragmatic language ability related to the amount of time getting to sleep; and duration of sleep related to parent-rated expressive and receptive communication difficulties. However, CCC Syntax was not related to sleep in either group suggesting that the whole sample correlation may be led by co-morbid but unrelated group differences in both sleep and syntax. See Table 2 for details.

[Table 2 about here]

### **Discussion**

The role of sleep in development is important, but not well understood especially in developmental disorders. This study provides evidence for a direct association between everyday sleep behaviours and language ability in a clinical population. It does this in two ways: Firstly, children with communication disorders showed more sleep difficulties than their typically developing peers; Second, sleep behaviours predicted expressive, receptive and social-language difficulties in both groups, and receptive communication in children with communication disorders. Sleep behaviours also related to other important developmental skills rated by parents such as attention and listening. Although at first syntax appears related, when groups were examined separately data suggests that syntax

and sleep may be co-occurring but unrelated characteristics of communication disorder, or that a more complex developmental causality is involved (i.e. that poor sleep at one age might lead to poor syntax at a later point, but not concurrently). Reading and writing were not correlated but this may be because of the relatively young age of the children being rated, or because parents are not as sensitive at judging these skills which are largely measured at school rather than at home.

This study supports previous evidence from children with autism that indicates increased sleep difficulties for that group (Mannion & Leader, 2014; Goldman et al, 2011; Mannion, Leader & Healy, 2013; Liu, Hubbard, Richard & Adam, 2006). However, it is to our knowledge one of the first to document sleep behaviours in children with language impairment, and to look at the relationship between language and sleep in either population. Findings support the one study that has reported a relationship between language delay and sleep (Dionne et al, 2011). Although eight of our group of children with CD had ASD, there were no differences between the ASD and LI groups on sleep behaviour, which suggests that sleep disturbance is a shared symptom between these groups. Parental report is a useful way to access information about sleep because sleep is a difficult behaviour to observe with any ecological validity. Studies carried out in sleep clinics are unlikely to reveal information about everyday sleep behaviour and may be disturbing for children with LI and autism. Nevertheless, parental report has obvious drawbacks: respondents cannot be blind to their child's diagnosis; they may over- or under-report certain behaviours; and in this study they are a self-selecting sample who may be particularly concerned about their child's sleep. Indeed, Herring et al.(1999) found that physiological sleep-pattern results of autistic children were similar to those in typically developing children, and concluded that parental over-sensitivity to sleep difficulties was the reason for their higher prevalence in surveyed sleep data. Despite this, parents have been reported to be highly accurate reporters of basic sleep schedule information (Sadeh, 1996) and the fact that our data does not show the signs of 'blanket' responses from parents (e.g., they did not report that *all* sleep behaviours were different) reassures us that the participants have answered in a reliable way, and that general 'over-sensitivity' has not driven the results. Furthermore, the relationship between sleep schedules and language ability is less susceptible to reporting bias.

Because the survey was anonymous and hosted online, a further limitation is that we only have parental report to confirm clinical status. Nevertheless, the parent report scales used from the CCC have been found to show good validity and reliability, and information was also gathered to confirm group membership, such as age of diagnosis and overall parental rating of communication. Not only are we confident therefore that the groups reported have difficulties pertaining to language, but our findings suggest that regardless of clinical status children who sleep well have better language skills. This dimensional approach to considering the relationship between sleep and language might be more informative.

Several studies into sleep duration/sleep efficiency and its effects on language processing in typically developing children have shown convincing associations (Dahl, 1996; Lim & Dinges, 2010; Gruber et al, 2014). It is possible therefore, that impoverished sleep has a role in poor language development, even within groups with communication disorders. Spending more time falling asleep could potentially interfere with the process of consolidation especially in the context of an already compromised language system. This would be in line with findings reported by Henderson et al (2012) who investigated the relationship between acquisition of words and sleep associated consolidation and concluded that declarative systems were particularly affected. In the current study, syntax and social communication problems were also related to sleep behaviour which may implicate other storage processes.

Alternatively, it is possible that children with language impairments experience poorer sleep alongside impaired communication because of other factors. These could include internal factors such as co-morbid anxiety which is common in LI (Conti-Ramsden & Botting, 2008) as well as in ASD (Simonoff et al, 2008). Furthermore, ADHD is one of the most frequently diagnosed comorbidities for both disorders. In this study, only 2 parents reported co-morbid ADHD and although this is known to be a risk factor for sleep problems (Schneider, Lam & Malone, 2016), this was not a factor driving the results in the current study. Nevertheless, it would be interesting in future studies to directly compare the sleep of children with communication disorders who do and do not have additional ADHD and or anxiety symptoms. Alternatively, external factors such as bedtime routines may play a role. For example, it is known that children with language impairment enjoy book-time less (Kaderavek & Sulzby, 1998), and since this is a regular component of pre-

bedtime relaxation in many UK homes, this may also contribute to an indirect association between language and sleep. Thus the relationships seen here between aspects of sleep behaviour and language could be mediated by other factors. Future studies should include a wider set of measures such as anxiety and bedtime routine to unpick this further. In addition, other variables that may relate to sleep should be investigated more comprehensively, in particular the role of socio-economic status and history of parental language difficulties.

### **Clinical implications**

The children in this study and the studies that have been explored have a common factor that is, the less they sleep, the poorer their language skill. Even in the case of a non-causal explanation for this association, one possibility is that improving these children's sleep patterns may also improve their language skills. Sleep intervention studies have indicated some success with other populations. For example, a study by Hiscock et al (2015) explored whether behavioural strategies designed to improve sleep problems could also improve the symptoms, behaviour and working memory of children with ADHD and achieved favourable results compared to a control group. In a similar vein, Quanch et al (2011) evaluated a behavioural sleep intervention for improving typically developing children's outcomes in their first year in schooling and found benefits relevant to school transition. Therefore health professionals involved with families who have communication disorders might consider suggesting interventions that involve sleep behaviour when advising on strategies that might ameliorate communication difficulties. At the very least, including questions about sleep behaviour when taking clinical histories may be useful. However we acknowledge that our study presents only preliminary data on this aspect of development in children with CD, and larger scale studies are now needed to inform practice, as well as studies that measure sleep physiologically.

This study has identified that children with a communication disorder have poorer sleep, and that sleep patterns relate directly to communication skills. In conclusion it is evident from the study that sleep is an important aspect of development which is sometimes neglected in the management of communication difficulties.

## **References**

- Axelsson, E. L., Williams, S. E., & Horst, J. S. (2016). The Effect of Sleep on Children's Word Retention and Generalization. *Frontiers in Psychology*, 7.
- Bishop, D.V.M. (1998) Development of the children's communication checklist (CCC): a method for assessing qualitative aspects of communicative impairment in children. *Journal of Child Psychology and Psychiatry*, 39.
- Bishop, D. V. M., Snowling, M. J., Thompson, P. A., & Greenhalgh, T. (2016). *CATALISE: a multinational and multidisciplinary Delphi consensus study. Identifying language impairments in children* (No. e1986v1). PeerJ Preprints.
- Bishop, D. V. M. (2014) Ten questions about terminology for children with unexplained language problems. *International Journal of Language and Communication Disorders*. 49, 381–415. doi:10.1111/1460-6984.12101
- Cohen, S., Conduit, R., Lockley, S. W., Rajaratnam, S. M., & Cornish, K. M. (2014). The relationship between sleep and behavior in autism spectrum disorder (ASD): a review. *Journal of neurodevelopmental disorders*, 6(1), 1.
- Cohen, N. J., Vallance, D. D., Barwick, M., Im, N., Menna, R., Horodezky, N. B., & Isaacson, L. (2000). The interface between ADHD and language impairment: An examination of language, achievement, and cognitive processing. *Journal of Child Psychology and Psychiatry*, 41(3), 353-362.
- Conti-Ramsden, G. and Botting, N. (2008) Risk of affective disorders in adolescents with a history of SLI. *Journal of Child Psychology and Psychiatry*, 49(5), 516-525.
- Conti-Ramsden, G., Simkin, Z. and Botting, N. (2006) The prevalence of ASD in adolescents with a history of SLI. *Journal of Child Psychology and Psychiatry*. 47(6)621-628.
- Dahl, R.E. (1996). The impact of inadequate sleep on children's daytime cognitive function. *Seminars in Pediatric Neurology*. 3 (1), 44-50.
- Dionne, G., Touchette, E., Forget-Dubois, N., Petit, D., Tremblay, R. E., Montplaisir, J. Y., & Boivin, M. (2011). Associations between sleep-wake consolidation and language development in early childhood: a longitudinal twin study. *Sleep*, 34(8), 987.
- Fenn, K.M., Nusbaum, H.C. & Margoliash, D. (2003). Consolidation during sleep of perceptual learning of spoken language. *Nature*. 425, 614-616.
- Goldman, S. E., McGrew, S., Johnson, K. P., Richdale, A. L., Clemons, T., & Malow, B. A. (2011). Sleep is associated with problem behaviors in children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 5(3), 1223-1229.

- Gruber, R., Somerville, G., Enros, P., Paquin, S., Kestler, M., & Gillies-Poitras, E. (2014). Sleep efficiency (but not sleep duration) of healthy school-age children is associated with grades in math and languages. *Sleep medicine*, 15(12), 1517-1525.
- Henderson, L.M., Weighall, A.R., Brown, H., Gaskell, G.M. (2012). Consolidation of vocabulary is associated with sleep in children. *Developmental Science*. 15 (5), 674-687.
- Herring, E., Epstein, R., Elroy, S., Iancy, D.R. & Zelnik, N. (1999). Sleep patterns in autistic children. *Journal of Autism and Developmental Disorders*. 29 (2), 143-147.
- Hiscock, H., Sciberras, E., Mensah, F., Gerner, B., Efron, D., Khano, S., & Oberklaid, F. (2015). Impact of a behavioural sleep intervention on symptoms and sleep in children with attention deficit hyperactivity disorder, and parental mental health: randomised controlled trial. *British Medical Journal*, 350, h68.
- Kaderavek, J. N., & Sulzby, E. (1998). Parent-child joint book reading: An observational protocol for young children. *American Journal of Speech-Language Pathology*, 7, 33-47.
- Kurdziel, L. B., Mantua, J., & Spencer, R. M. (in press, 2016). Novel word learning in older adults: A role for sleep? *Brain and Language*.
- Liu, X., Hubbard, J.A., Richard, F.A, Adam, B.J. (2006). Sleep Disturbances and Correlates of Children with Autism Spectrum Disorders. *Child Psychiatry and Human Development*. 37 (2), 179-191.
- Lim, J. & Dinges, D.F. A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin*. 2010; 136: 375-389.
- Malow, B. A., Katz, T., Reynolds, A. M., Shui, A., Carno, M., Connolly, H. V., ... & Bennett, A. E. (2016). Sleep Difficulties and Medications in Children With Autism Spectrum Disorders: A Registry Study. *Pediatrics*, 137(Supplement 2), S98-S104.
- Mannion, A., & Leader, G. (2014). Sleep problems in autism spectrum disorder: a literature review. *Review Journal of Autism and Developmental Disorders*, 1(2), 101-109.
- Mannion, A., Leader, G., & Healy, O. (2013). An investigation of comorbid psychological disorders, sleep problems, gastrointestinal symptoms and epilepsy in children and adolescents with autism spectrum disorder. *Research in Autism Spectrum Disorders*, 7(1), 35-42.
- Polimeni, M.A., Richdale, L.A. & Franc, J.A.P. (2005). A survey of sleep problems in autism, Asperger's disorder. *J of Intellectual Disability Research* 49, 260-368.
- Quanch, J., Hiscock, H., Ukomunne, C.O. & Wake, M. (2011). A brief sleep intervention improves outcomes in the school entry year: a randomised controlled trail. *Pediatrics*. 128 (4), 692-701.



- Robinson, A.M. & Richdale, A.L. (2004). Sleep problems in children with an intellectual disability: parental perceptions of sleep problems, and views of treatment outcomes. *Child Care Health and Development*. 30 (2), 139-50.
- Sadeh, A. (1996) Evaluating night wakings in sleep-disturbed infants: a methodological study of parental reports and actigraphy. *Sleep*, 19, 757-762.
- Schneider, H. E., Lam, J. C., & Mahone, E. M. (2016). Sleep Disturbance and Neuropsychological Function in Young Children with ADHD. *Child Neuropsychology: A Journal on Normal and Abnormal Development in Childhood and Adolescence*, 22(4), 493–506. <http://doi.org/10.1080/09297049.2015.1018153>
- Schreck, K.A. & Mulick, J.A . (2000). Parental reports of sleep problems in autism. *Journal of Autism and Developmental Disorders*. 30, 127-35.
- Simon, K. N., Werchan, D., Goldstein, M. R., Sweeney, L., Bootzin, R. R., Nadel, L., & Gómez, R. L. (in press, 2016). Sleep confers a benefit for retention of statistical language learning in 6.5 month old infants. *Brain and Language*.
- Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child & Adolescent Psychiatry*, 47(8), 921-929.
- Tamminen, J.J., 2010. *Learning new words: effects of meaning, memory, consolidation, and sleep*, The University of York (United Kingdom)
- Taylor, B., Jick, H., & MacLaughlin, D. (2013). Prevalence and incidence rates of autism in the UK: time trend from 2004–2010 in children aged 8 years. *BMJ open*, 3(10), e003219.
- Taylor, M. A., Schreck, K. A., & Mulick, J. A. (2012). Sleep disruption as a correlate to cognitive and adaptive behavior problems in autism spectrum disorders. *Research in developmental disabilities*, 33(5), 1408-1417.
- Tomblin, J.B., Records, N.L., Buckwalter, P., Zhang, X., Smith, E., & O'Brien, M. (1997). Prevalence of specific language impairment in kindergarten children. *Journal of Speech, Language, & Hearing Research*, 40(6), 1245-1260.
- Williams, D., Botting, N. and Boucher, J. (2008) Language in autism and specific language impairment: Where are the links? *Psychological Bulletin*, 134(6), 944-963.
- Williams, S.E. & Horst, J.S. (2014). Goodnight book: sleep consolidation improves word learning via storybooks. *Frontiers in Psychology*, 5 (184)

Table 1: Mean (SD) parent ratings of developmental difficulties\*

|                          | TD group    | CD group    | Statistics             |
|--------------------------|-------------|-------------|------------------------|
| Expressive communication | 1.78 (0.95) | 3.64 (1.06) | t(63)=-7.4,<br>p<0.001 |
| Receptive communication  | 1.65 (0.89) | 3.50 (1.11) | t(63)=-7.5,<br>p<0.001 |
| Social communication     | 1.92 (0.95) | 3.64 (1.13) | t(63)=-6.7,<br>p<0.001 |
| Non-verbal communication | 2.19 (0.94) | 3.25 (1.27) | t(63)=-3.9,<br>p<0.001 |
| Attention and listening  | 2.41 (1.12) | 4.00 (0.82) | t(63)=-6.4,<br>p<0.001 |
| Memory                   | 1.73 (0.90) | 3.14 (1.41) | t(63)=-4.9,<br>p<0.001 |
| Reading                  | 2.76 (1.42) | 3.79 (1.37) | t(63)=-2.9,<br>p=0.005 |
| Writing                  | 2.73 (1.34) | 4.07 (1.11) | t(63)=-4.3,<br>p<0.001 |

\* 1-5 scale where higher scored = more reported difficulties

Table 2: Correlations between sleep behaviour and communication/developmental skills  
Whole sample in bold, TD group in normal type, CD group in italics

|                          | Time getting off to sleep |      |             | Duration of sleep |       |              | Night wakings |      |             |
|--------------------------|---------------------------|------|-------------|-------------------|-------|--------------|---------------|------|-------------|
| CCC speech problems      | <b>0.26</b>               | 0.18 | <i>0.14</i> | <b>-0.20</b>      | -0.10 | <i>-0.05</i> | <b>0.02</b>   | 0.11 | <i>0.24</i> |
| CCC syntax problems      | <b>0.27*</b>              | 0.02 | <i>0.07</i> | <b>-0.17</b>      | -0.06 | <i>-0.06</i> | <b>0.07</b>   | 0.09 | <i>0.08</i> |
| CCC coherence problems   | <b>0.45**</b>             | 0.28 | <i>0.31</i> | <b>-0.25</b>      | -0.11 | <i>-0.17</i> | <b>0.14</b>   | 0.13 | <i>0.16</i> |
| Expressive communication | <b>0.37**</b>             | 0.24 | <i>0.03</i> | <b>-0.37**</b>    | -0.31 | <i>-0.30</i> | <b>0.16</b>   | 0.19 | <i>0.13</i> |
| Receptive communication  | <b>0.43**</b>             | 0.19 | <i>0.24</i> | <b>-0.35**</b>    | -0.21 | <i>-0.34</i> | <b>0.26*</b>  | 0.41 | <i>0.17</i> |
| Social communication     | <b>0.34**</b>             | 0.34 | <i>0.16</i> | <b>-0.34**</b>    | -0.18 | <i>-0.33</i> | <b>0.24</b>   | 0.13 | <i>0.18</i> |
| Non-verbal communication | <b>0.28*</b>              | 0.24 | <i>0.02</i> | <b>-0.26*</b>     | -0.15 | <i>-0.21</i> | <b>0.23</b>   | 0.28 | <i>0.19</i> |
| Attention and listening  | <b>0.32**</b>             | 0.04 | <i>0.26</i> | <b>-0.24</b>      | -0.06 | <i>-0.23</i> | <b>0.29*</b>  | 0.37 | <i>0.17</i> |
| Memory                   | <b>0.28*</b>              | 0.02 | <i>0.14</i> | <b>-0.29*</b>     | -0.34 | <i>-0.12</i> | <b>0.26*</b>  | 0.37 | <i>0.21</i> |
| Reading                  | <b>0.16</b>               | 0.01 | <i>0.05</i> | <b>-0.03</b>      | -0.03 | <i>-0.08</i> | <b>0.06</b>   | 0.12 | <i>0.07</i> |
| Writing                  | <b>0.23</b>               | 0.10 | <i>0.23</i> | <b>-0.16</b>      | -0.04 | <i>-0.19</i> | <b>0.10</b>   | 0.13 | <i>0.07</i> |

\*p<0.05 \*\*p<0.01

Dark grey shaded boxes indicate significant relationships that are present in both groups

Light grey shaded boxes indicate significant relationships that are present in one group